

What is claimed is:

1. An internal combustion engine ignition apparatus, comprising:

an ignition coil having a primary coil and a secondary coil; and

a switching circuit which interrupts a current of the primary coil of the ignition coil on the basis of an ignition signal voltage to generate a high voltage for ignition in the secondary coil of the ignition coil, wherein

the ignition signal voltage is a pulse-like voltage including a rising portion and a falling portion,

the switching circuit has no power supply terminal connected to a battery and includes an output terminal connected to the primary coil of the ignition coil, an input terminal for receiving the ignition signal voltage, and a reference potential terminal,

the switching circuit includes a switching element which is connected between the output terminal and the reference potential terminal, applies a current to the primary coil of the ignition coil in an on state, and interrupts the current of the primary coil when an off state is caused, a drive resistor for the switching element, a current supply circuit which is connected between the input terminal and the reference potential terminal and supplies a driving current to the drive resistor, and a waveform shaping circuit which controls the driving current

from the current supply circuit to the drive resistor, brings the switching element into the on state on the basis of supply start of the driving current, and brings the switching element into the off state on the basis of supply interruption of the driving current, and

the waveform shaping circuit includes a comparison signal generation circuit for generating a comparison signal on the basis of the ignition signal voltage, and a reference signal generation circuit for generating a reference signal on the basis of the ignition signal voltage, starts to supply the driving current to the drive resistor when the comparison signal becomes larger than the reference signal in the rising portion of the ignition signal voltage, and interrupts the driving current when the comparison signal becomes smaller than the reference signal in the falling portion of the ignition signal voltage.

2. An internal combustion engine ignition apparatus according to claim 1, wherein the switching circuit includes an ignition signal line connected to the input terminal, and a reference potential line connected to the reference potential terminal, and both of the current supply circuit and the waveform shaping circuit are connected between the ignition signal line and the reference potential line.

3. An internal combustion engine ignition apparatus according to claim 2, wherein the current supply circuit includes

an output transistor for supplying the driving current, and a control transistor for on/off controlling the output transistor, the waveform shaping circuit includes a comparator for comparing the comparison signal with the reference signal, and the control transistor is controlled on the basis of an output of the comparator to control the driving current.

4. An internal combustion engine ignition apparatus according to claim 3, wherein the waveform shaping circuit further includes a level up circuit operating in accordance with the output of the comparator, and the level up circuit raises a level of the comparison signal when the supply of the driving current is started in the rising portion of the ignition signal voltage.

5. An internal combustion engine ignition apparatus according to claim 2, wherein the current supply circuit further includes a constant current circuit connected between the ignition signal line and the reference potential line, the constant current circuit generates a constant current on the basis of the ignition signal voltage and causes the driving current supplied from the current supply circuit to the drive resistor to become constant.

6. An internal combustion engine ignition apparatus according to claim 5, wherein the constant current circuit includes a constant current transistor for generating the constant current, and the constant current transistor is

connected to the output transistor to perform constant-current driving of the output transistor of the current supply circuit.

7. An internal combustion engine ignition apparatus according to claim 2, wherein the switching circuit further includes a current limiting circuit for limiting a flowing current of the switching element.

8. An internal combustion engine ignition apparatus according to claim 7, wherein the current limiting circuit includes a flowing current detection circuit for detecting the flowing current of the switching element, reduces the driving current from the current supply circuit to the drive resistor depending on an increase of the flowing current, and reduces the flowing current of the switching element.

9. An internal combustion engine ignition apparatus according to claim 8, wherein the switching element is an IGBT, the switching element includes an emitter and an auxiliary emitter, and the flowing current detection circuit is connected to the auxiliary emitter.

10. An internal combustion engine ignition apparatus according to claim 8, wherein the switching element is an IGBT having a sense IGBT, and the flowing current detection circuit is connected to the sense IGBT.

11. An internal combustion engine ignition apparatus according to claim 7, wherein the current limiting circuit includes an output voltage detection circuit for detecting an

output voltage at the output terminal, and changes a current limiting characteristic for the switching element depending on the detected voltage of the output voltage detection circuit.

12. An internal combustion engine ignition apparatus according to claim 11, wherein the output voltage detection circuit includes a voltage changing unit for changing the detected voltage stepwise as the output voltage is increased, and the current limiting characteristic for the switching element is changed stepwise.

13. An internal combustion engine ignition apparatus according to claim 12, wherein a bent point is provided in the current limiting characteristic, and in a region of the output voltage at a side lower than the bent point, as compared with a region of the output voltage higher than the bent point, an inclination of the flowing current of the switching element with respect to the output voltage is made small.

14. An internal combustion engine ignition apparatus according to claim 11, wherein the switching element is an IGBT, and the output voltage detection circuit is connected to a latch-up transistor constructed in the IGBT.

15. An internal combustion engine ignition apparatus according to claim 2, wherein the switching circuit includes an output voltage detection circuit for detecting an output voltage at the output terminal, and when the output voltage is increased, a flowing current of the switching element is

reduced or interrupted.

16. An internal combustion engine ignition apparatus according to claim 2, wherein the switching circuit includes an over-energization protection circuit, and when an energization time of the switching element becomes equal to or longer than a specified time, the over-energization protection circuit turns off the switching element.

17. An internal combustion engine ignition apparatus according to claim 2, wherein the switching circuit includes a current limiting circuit for limiting a flowing current of the switching element, a output voltage detection circuit for detecting a voltage at the output terminal and reducing the current of the switching element when the voltage at the output terminal is increased, and an over-energization protection circuit for turning off the switching element when an energization time of the switching element becomes a specified time or longer.

18. An internal combustion engine ignition apparatus according to claim 17, wherein the current limiting circuit, the output voltage detection circuit, and the over-energization protection circuit, together with the current supply circuit and the waveform shaping circuit, are integrated on a common semiconductor substrate.